

REMARKS

In light of the previous Amendments and following Remarks, allowance of the above-captioned application is respectfully requested.

Claims 1-5, 8-25, and 34-41 are pending in the application, including independent claims 1, 17, and 34. In response to the Restriction Requirement, Applicants, through and by their representative, elect the claims of Invention I, claims 1-25, drawn to a process for forming branched nanotubes, for examination on the merits. Accordingly, Applicants have canceled claims 26-33, without traverse, as directed to a non-elected invention.

In the Office Action, dependent claim 7 was objected to as being dependent upon a rejected base claim. Accordingly, claim 1 has been amended to incorporate all of the limitations of claim 7. As such, Applicants respectfully request allowance of claims 1-5 and 8-16.

In the Office Action, it was stated that independent claim 17 would be allowable in light of certain amendments. Accordingly, claim 17 has been amended to include the limitations of an iron catalyst, a dopant selected from the group of titanium, hafnium, and zirconium, and a bimetal catalyst particle including iron and the dopant. As such, Applicants respectfully request allowance of claims 17-25.

New claims 34-41 are directed to a multi-stage process for forming the branched carbon nanotubes of the invention. Support for these new claims can be found throughout the application, for instance in the discussion at paragraphs 43-47. For example, new independent claim 34 is directed to a process including a first growth stage in which a catalyst and a carbon source are provided to a reactor, the catalyst and the carbon source are vaporized, and a carbon nanotube is formed according to a chemical-vapor deposition method. During this first growth stage, the carbon nanotube develops with no branching. The process also includes a second growth stage. During the second growth stage, a dopant is also provided to the reactor, and doped catalyst particles are formed including both the dopant and the catalyst. Only during the second of the two growth stages are both the catalyst and dopant supplied to the reactor. During this second growth stage, one or more branches develop on the carbon nanotube. Thus, branching of the nanotubes can

be controlled through the addition or removal of the dopant in the reactor during the CVD process.

None of the cited references disclose or suggest a multi-stage growth process in which the reactor feed can be altered during the process in order to control the morphology of the developing carbon nanotube as is found in new claims 34-41. For instance Baker, et al. (U.S. Patent 5,618,875) discloses a formation method in which the catalyst can either be supported, i.e., deposited on a substrate prior to the formation process in the form of a catalyst precursor (col. 4, l. 54 – col. 5, l. 11), or unsupported, in which case the catalyst is provided in a volatile form for deposition from the vapor phase (col. 5, ll. 44-48). However, the catalyst system is homogeneous throughout the growth process, with no suggestion of altering in the chosen catalyst system throughout the process.

Hong, et al. (U.S. Patent Application Publication No. 2002/0127170), similar to Baker, et al. discloses that the catalysts can be loaded on a support, a substrate, or supplied in gas phase, but does not describe any alteration in the catalyst during the growth of the carbon nanotubes.

Similarly, Komatsu, et al. (U.S. Patent No. 4,816,289) teaches that though any method may be employed for introducing the organic transition metal compound or the transition metal salt or complex and the raw material hydrocarbon into the heating zone, "it is extremely important that they are introduced in the form of a homogeneous mixture" (col. 17, ll. 28-45). Komatsu, et al. does describe the possibility of the inclusion of a filament forming auxiliary to the process (col. 25, l. 22 – col. 26, l. 21). However, the auxiliary is supplied into the heating zone either via a carrier gas or with the hydrocarbon compound, and there is no teaching that the addition of an auxiliary component is supplied during a stage of a multi-stage growth process in order to affect the morphology of the developing carbon nanotube, as is found in the present claims.

It is believed that the present application is in complete condition for allowance and favorable action, therefore, is respectfully requested. Examiner Raetzsch is invited and encouraged to telephone the undersigned, however, should any issues remain following consideration of this response.


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Reply to Office Action of December 27, 2005

Please charge any additional fees required by this Response to Deposit Account
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Respectfully submitted,

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Date


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